HISTORY OF THE CARIBBEAN ISLANDS FROM A PETROGRAPHIC POINT OF VIEW (Abstract).

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Bibliography.[1]

Our knowledge of the geological history of the Antilles is still very imperfect. Among the titles constituting the bibliography of this subject are:

Topography and Geology of Santo Domingo. By William M. Gabb. *Trans. Am. Phil. Soc.*, XV, n. s. (1871).

Observations and a Physico-Geological Description of the Regions of Habana and Guanabacoa. Salterain, Madrid, 1880.

A Pamphlet and Geological Map of Cuba, by Don Manuel Fernandez de Castro, based on work commenced in 1869. Madrid, 1881.

On the Mountains of Eastern Cuba. W. O. Crosby, 1882.

Archean Character of Rocks of the Nucleal Ranges of the Antilles. Persifor Frazer. *Bath Meeting B. A. A. S.*, 1888.

Coleccion de apuntes sobre la riqueza minera de la provincia de Santiago de Cuba. Published by Juan E. Ravelo. Sant. de Cuba, 1893.

Reconstruction of the Antillean Continent. J. W. Spencer. *Bull. G. S. A.*, August 14, 1894.

Geographical Evolution of Cuba. *Id.* December 27, 1894.

Zur Geologie von San Domingo. W. Bergt. *Abhandlung der naturw. Gesell. "Isis" in Dresden*, 1897.

Cuba and Porto Rico, with the Other Islands of the West Indies. Robert T. Hill. The Century Co., New York, 1898.

(This last work is a compendium of information on the subject and contains an extensive bibliography of the less scientific and more descriptive treatises on the West Indies.)

At the Bath meeting of the British Association for the Advancement of Science in 1888 I presented numerous rock specimens and thin sections cut from them, illustrating a region of about forty miles around Santiago de Cuba. The rocks were partly eruptives and partly classic, but almost all exhibited profound alteration. The thin sections from these eruptives were examined with me by Dr. Hensoldt, Mr. Kunz and Mr. La Croix in this country, and later by Mr. Teall, Mr. Rudler, the Abbé Renard, Prof. Judd and the lamented Prof. George H. Williams in London; all of whom were practically agreed as to the main constituents.

The specimens were divided into:

A. Those from the hills containing the West mine of the Jurugua

[1] A more detailed statement of the observations, in the field and with the microscope, on which these conclusions are based will be published later.—P. F.

Iron Co., near Firmeza. (1) Diorites, some of which contained much altered hornblende and viridite (chlorite), the thin slides filled with microlites and the rocks traversed by epidote veins. (2) Dolerites, diabase (gabbros), with chloritic ground mass, magnetite, rods of feldspar and some olivine.

B. From the hills southeast of that in which the "East mine" was located and about fifteen miles northeast of Santiago de Cuba. (1) Garnet rocks with iron ore (sp. gravity 3.962). (2) Fibrous actinolite, and brown iron oxides partially altered to an epidotic mass. (3) Iron ores (some showing cross lines like the Widmanstätten figures in meteoric iron).

C. From the Sietes Altarés, about thirty-five miles east of Santiago de Cuba. Orthofelsite porphyry (rhyolites), like those erroneously referred to by the late Prof. H. D. Rogers as "jasper," and later recognized by the late Dr. T. Sterry Hunt as a mixture to which he gave the general name "orthophyre"; also like the Arvonian tuffs of Hicks, near St. David's Head, Pembrokeshire, Wales.

D. The specimens from the region of the La Plata mines were quartzites containing hornblende, iron ores and, among the incidental minerals, a claret-red garnet.

In the area described were found upon or associated with the eruptives sandstones, conglomerates and crystalline limestones, laminated iron ores with masses of pyrites not yet converted into the latter. The alteration of the areas of contact in these rocks by the more recent diorite dykes which cut them was evident.

From the character and relations of these rocks I deduced a physical continuity between the Archean of the mainland of the North American continent and the skeleton of the Cuban orographic system.

From the zoölogical and geological researches of Alexander Agassiz in Caribbean and Mexican waters, and the careful studies by Gabb, Crosby, Spencer and Hill, the probability of very great changes of level in the Antilles since the close of the Cretacic period was established, and this probability is fortified by several different lines of proof, *i.e.*, the ledges and shelves of the island borders, the wide distribution of the white radiolarian limestones, etc., and finally petrographic examinations of material from the several islands.

Prof. Crosby pointed out orographic reasons for assuming a former "bridge" (*i.e.*, causeway) between the Greater and Lesser Antilles. As he says, the mountains of "the northern arm of the island of San Domingo point toward Cape Maysi on Cuba," and the northern range in Cuba "regains the western trend and points directly toward Yucatan."

He also alludes in his paper of December 13, 1882, to the "axis of old eruptive rocks" of which, so far as he has been able to learn, "each member of the group consists." He does not give his authority for this statement nor say to what age he ascribes these eruptives; but if he contemplated the possibility of its being pre-Cambrian he anticipated by six years two of the strongest grounds for my belief in the physical continuity of the Great and Little Antilles, and the present exposure of parts of the nucleus which are of great age and possibly have never been covered by sedimentary rocks.

His observation that this nucleus is flanked on either side by schists and slates has been fully confirmed, and I have been tempted to class these with the mica schists of the Appalachians, and the feldspar porphyry (rhyolites) with the Arvonian tuffs of south Wales.

Dr. W. Bergt strongly supports the Archean age of the nucleal axis of San Domingo if not of all the Caribbean Islands in the following words:[2]

"Das archäische Alter welches P. Frazer für die Centralketten des südöstlichen Cuba feststellen konnte, und das er für ganz Jamaika, für San Domingo, Puerto Rico, und die Windwardinseln vermuthete, kann nunmehr bestimmter für San Domingo angenommen werden."

It may be, as Mr. Hill suggests, that no "Paleozoic nucleal rocks" have been established with certainty in "Cuba and Santo Domingo" or any other of the border lands of the "American Mediterranean,"[3] although de Castro imagined he had discovered such near Cienfuegos, yet this fact would not preclude the possibility that part of these nucleal rocks are pre-Cambrian.

To summarize the observations:

(1) There is a complex of diorite, felsite and rhyolite forming the axes of the mountain ranges of eastern Cuba.

(2) With these are associated schists which in places assume a gneissoid character.

(3) The diorite and the clastic rocks resting on it are traversed by numerous veins of later eruptives, on the contact planes of which latter many phenomena of alteration may be observed.

(4) No such indications of alteration are apparent at the contacts with the older diorite mass, but, on the contrary, the sedimentary rocks seem to have been deposited upon it without disturbance.

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[2] "Zur Geologie von San Domingo." *Abh. der naturw. Gesel. "Isis" in Dresden*, 1897, Heft II, p. 64.

[3] *Cuba and Porto Rico*, p. 384.

(5) All the rocks earlier than the intrusive veins, and even parts of these latter, show extensive alteration and probable transformation.

One purpose of this abstract is to recall the fact that we have proofs of physical connection with the Western Continent of these outlying islands, not only from the physiographic features; drowned valleys; submerged plateaus; trend of conformation through the major axes of the present detached islands; palæontological analogy with South American forms of life; etc., but, in addition to all these, the close petrographical relationship of the crystallized and crystalline rocks and their congeners with those of the mainland.

Note.

A paper has just been received from Dr. Callaway (December 27, 1902) on the Plutonic complex of Central Anglesey,[4] in which some very curious resemblances appear between the central complexes of Anglesey and Cuba, dissimilar as are the more recent mantles with which in the two cases these nuclei are clothed.

In 1880 Dr. Callaway, in entire accord with Dr. Hicks and many of the non-official geologists of Great Britain as well as of our compatriot, Dr. T. Sterry Hunt, had established the pre-Cambrian age of these Anglesey rocks. In 1888 the Rev. J. F. Blake had confirmed a note previously made by Dr. Callaway of the production of schistosity in diorite by pressure. In the eastern district of Anglesey Dr. Callaway considers felsite and diorite the materials out of which the gneiss was made: "but with them is associated the well-known binary granite (haplite) originally called Dimetian by the late Dr. Hicks. A fourth variety . . . . is the quartz-felsite claimed by that geologist as Arvonian. It forms a part of the same magma as the granite, and must be carefully distinguished from quartzless felsite, into which it is sometimes intruded in dykes and veins."

After dividing the diorite and its modifications into hornblende-gneiss, decomposed diorite and chlorite-gneiss, micaceo-chloritic gneiss, and kersantite and biotite-gneiss, he says of the felsite that he "has never succeeded in obtaining a specimen in its original state," and in analysis it is almost indistinguishable from Vom Rath's rhyolite of the Euganean Hills, and from a rhyolitic obsidian from Medicine Lake. With the above are associated crystalline limestones, of which the origin, according to Dr. Callaway, is chemical segregation and not sedimentation.

[4] *Quart. Journ. Geol. Soc.*, Vol. lviii, 1902.

The granite (haplite) and quartz-felsite, according to him, are intruded into the diorite and felsite after the production of schistosity.

Seams of quartz and feldspar (haplite) alternate with seams of biotite and feldspar (modified diorite) when the veins lie in the planes of shearing of the diorite, and the result is a banded gneiss.

The quartz-felsite forms part of the same magma as the granite. Of two thin slides of the gneiss formed by schistose felsite intersected by numerous granite veins, Prof. Bonney "thinks much of the mica secondary."

The paper concludes thus: "The following would seem to have been the sequence of events in the central complex. Diorite was first consolidated. It was then penetrated by masses and veins of felsite, and blocks of it were isolated from the main mass (or masses) and floated off into the felsite. The consolidation of the felsite was the next stage. Earth-pressures then affected both diorite and felsite, producing schistosity. A granite magma, usually haplite, sometimes quartz-felsite, then invaded the area, penetrating the diorite and the felsite in large masses, and sending into them countless veins, which commonly found their way along planes of schistosity, giving rise to banded gneisses."

Summary of Results.

"(1) The central complex of Anglesey was originally composed of diorite, felsite and granite.

(2) The diorite has been modified into an elliptical dome of dark gneiss, namely, into simple gneisses by pressure, and into complex gneisses by pressure *plus* granitic intrusion.

(3) The intrusion of the granite into the diorite has often produced fusion at the contact, sometimes with the generation of biotite in the diorite.

(4) The diorite and dark gneiss form an insular mass surrounded by granite.

(5) The felsite has been modified into quartzose and micaceous schists and gneisses by pressure, and into banded gneisses by the addition of granitic intrusions.

(6) The quartz-felsites of the area are a part of the granitic magma.

(7) Both diorite and felsite were modified into gneisses and schists prior to the intrusion of the granite and quartz-felsite, which are not foliated."